general form of the body and the segmentation is not unlike in the two genera; and especially to be noted is a resemblance in the scolex. In the present genus as in the *Oochoristica* from *Tamandua tetradactyla*, described by myself* some months since, the strobila, as it were, invade the scolex. On the other hand, the *early* disappearance of the uterus and the imbedding of the ova *singly* in the medullary parenchyma is a character of *Oochoristica* which distinguishes it from the genus which I propose to call *Anoplotænia*. The peculiar cirrus sac and the very complex genital cloaca are points in which *Anoplotænia* differs from all the genera with which I here compare it.

There now remains the genus *Tænia* (*sensu stricto*) to which the present species shows a certain amount of likeness in the uterus, which is rather pronounced in certain proglottids. There is in fact occasionally a quite distinct median stem with branches. *Tænia*, however, has an armed rostellum which is sometimes not armed as in *T.* (*Tæniarhynchus*) *saginata*, where the hooks drop out early and are replaced by a sucker-like structure†. There is nothing of this kind in the present species, which moreover bears no such close likeness to *Tænia saginata* as would warrant its inclusion in the same genus or subgenus. Another genus in which the uterus has a marked median stem and lateral branches is *Catenotænia*,‡ the species of which occur in the mouse and in the squirrel. In this genus, however, the testes and ovaries have a different position from that which is met with in the tapeworm dealt with in the present memoir, and the relation of the genital duct to the excretory tubes is also different.

46. Some Madreporaria from the Persian Gulf. By Ruth Harrison, Oxford §. With a Note on the Memoir and some Further Notes on *Pyrophyllia inflata* by Sydney J. Hickson, M.A., D.Sc., F.R.S., F.Z.S.

[Received May 19, 1911: Read June 27, 1911.]

(Plates LVII. & LVIII. ‖ and Text-figures 216–221).

This collection of Madreporarian corals was made by Mr. F. W. Townsend, and entrusted to me for identification and description by Professor Hickson. I should like to take this opportunity of thanking Professor Hickson for putting this interesting piece of work in my hands. My thanks are also due to Professor Bourne for allowing me to carry on the work in his laboratory and placing all its resources at my disposal, and for help and advice during the

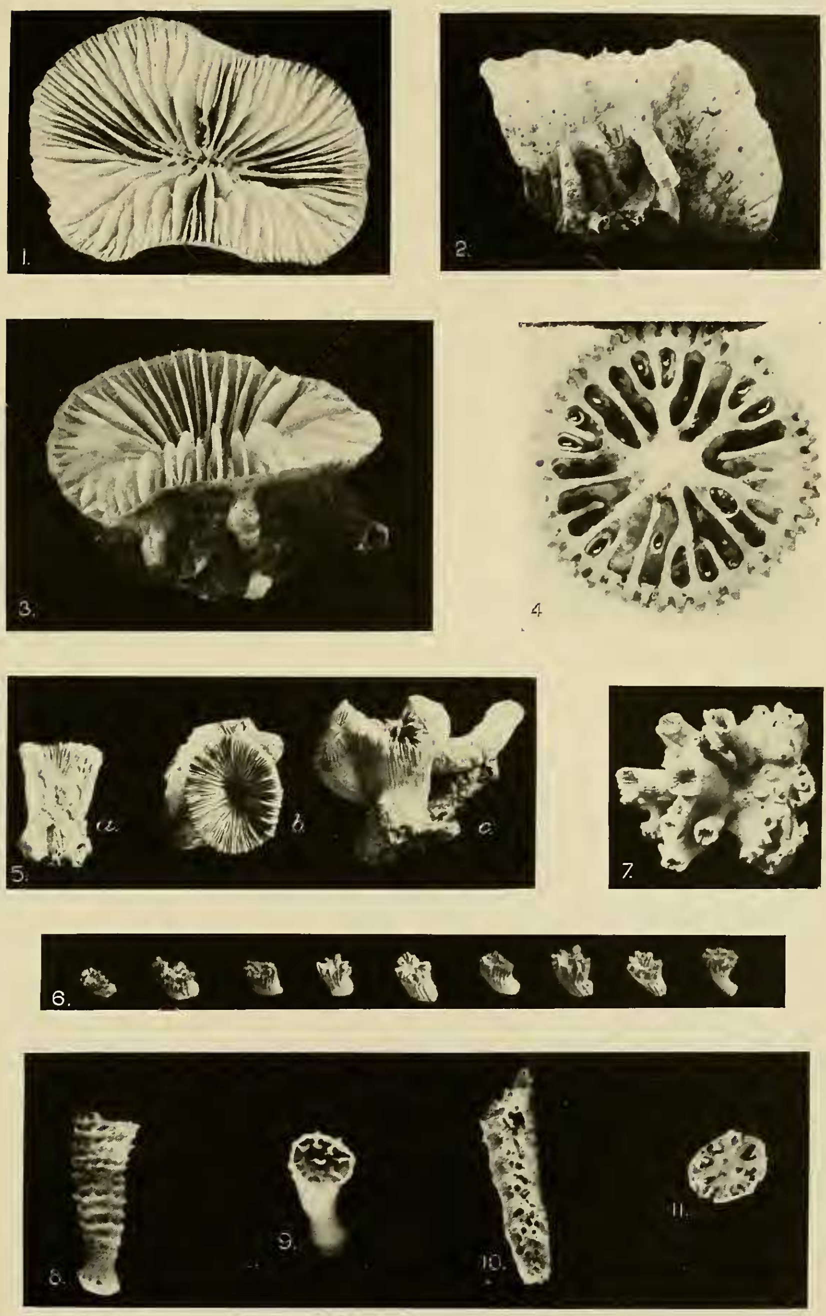
* P. Z. S. 1911, p. 627. I ought to have mentioned in that paper that something of the same kind appears to occur in *O. rostellata* (see Zschokke, Zeitschr. wiss. Zool. vol. lxxxiii. 1905).

† *Cf.* Bronn's "Thierreich," Vol. iv. Abth. B. p. 1720.

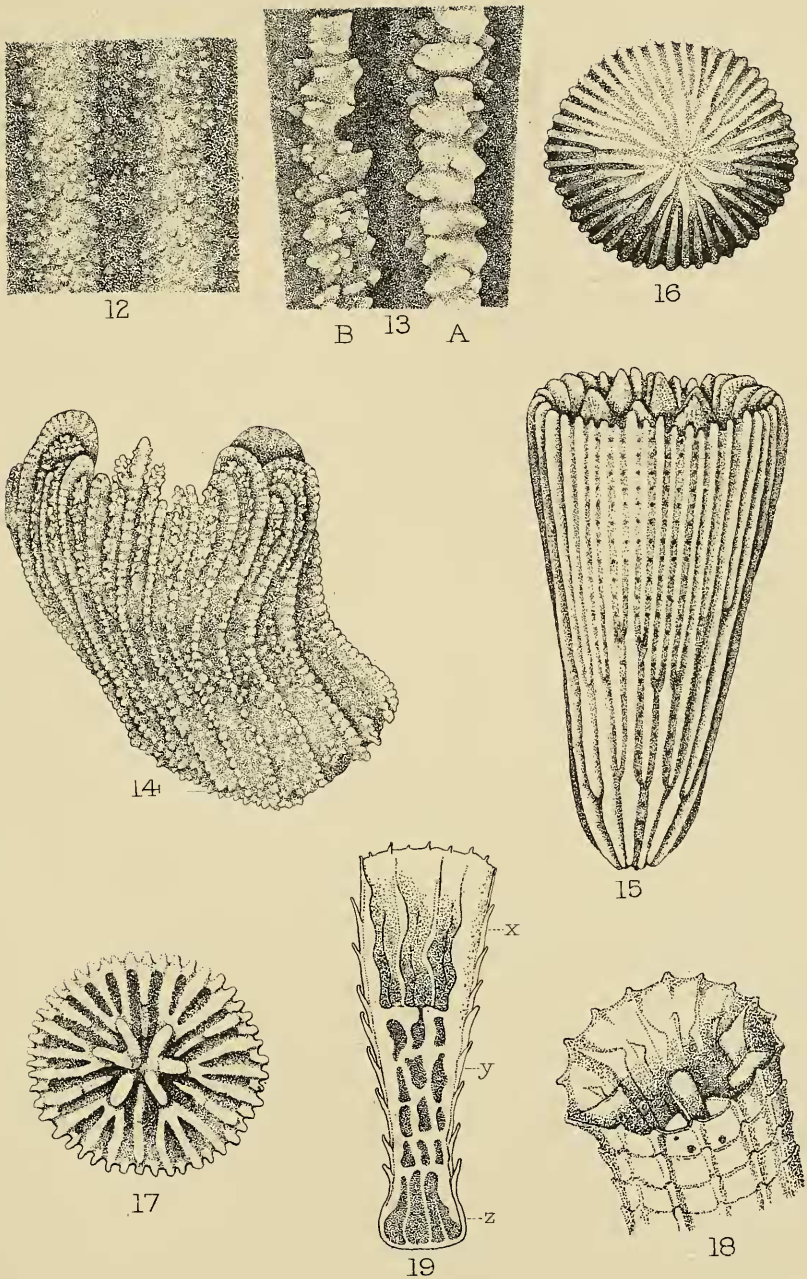
‡ Janicki, Zeitschr. wiss. Zool. 1906, vol. lxxxi. p. 505.

§ Communicated by Prof. S. J. Hickson, F.R.S., F.Z.S.

‖ For explanation of the Plates see p. 1044.



MADREPORARIA FROM THE PERSIAN GULF.



MADREPORARIA FROM THE PERSIAN GULF.

Bale & Danielsson, Ltd imp.

progress of the work; to Professor Sollas for permission to use his apparatus, which enabled me to grind sections, photograph and reconstruct a wax model of *Trematotrochus zelandiæ*; to Professor Jeffrey Bell for permission to examine various Madreporaria in the British Museum; and to Professor Stanley Gardiner for the loan of a large number of his specimens of *Heterocyathus æquicostatus* for comparison with the present collection.

The collection consists of examples of the following species:—

Family GUYNIIDÆ.

Pyrophyllia inflata Hickson [**25**].

Family FLABELLIDÆ.

Flabellum magnificum v. Marenzeller [**28**].

Family TURBINOLIIDÆ.

Heterocyathus æquicostatus Milne-Edwards & Haime [**29**].
Heterocyathus heterocostatus, sp. n.
Paracyathus cavatus Alcock [**1**].
Trematotrochus zelandiæ Duncan [**14**].
Agelecyathus persicus Duncan [**14**].

Family FUNGIIDÆ.

Fungia patella Milne-Edwards & Haime [**29**].

Family EUPSAMMIIDÆ.

Heteropsammia aphrodes Alcock [**1**].
Dendrophyllia sp.?

All these specimens are in the Manchester Museum. The occurrence of a recent *Trematotrochus* is worthy of special attention. Hitherto, the genus has been known from seven fossil and one recent species from Australia and Australasian seas, and it is remarkable to find it appearing in so remote a locality as the Persian Gulf. More remarkable still is the fact that this very species has already been described from Cook's Strait, New Zealand, by Professor Martin Duncan under the name of *Conocyathus zelandiæ*. The resemblance of the coral I have been examining to the figures and description (so far as it went) of this *Conocyathus* was so striking, that it occurred to me that possibly Duncan had overlooked the perforations of the wall, characteristic of a *Trematotrochus*. Owing to the kindness of Professor Jeffrey Bell I have been able to re-examine the original type specimens in the British Museum, and the result of this examination has been to convince me that the corals are absolutely identical. The British Museum species have not been so carefully cleaned and dried as those in the present collection, and in places the intercostal furrows are somewhat choked up by sand and grit; but that perforations do exist, exactly similar to those of the Persian Gulf species, I have no hesitation in stating; in parts of the corallum they are clearly visible, but unless one were expecting to find them it would be very easy to overlook them, and it is not altogether surprising that Duncan should have done so. Had he observed them, I venture to think he would not have called the coral a *Conocyathus*. In his ‘Revision of Families and Genera’ he places *Conocyathus*, *Trematotrochus*, and *Turbinolia* together as closely allied forms; indeed the perforations of the theca of *Trematotrochus* form the only feature which separates it from *Conocyathus*. Now that perforations have been observed in *Conocyathus zelandiæ*, we must either amend the definition of that genus, or else remove this species to the genus *Trematotrochus*. The existence of pores is a character of such importance that the latter course seems to me advisable, and in future *Conocyathus zelandiæ* should be known as *Trematotrochus zelandiæ*. The specific name is unfortunate and apt to be misleading, as is bound to be the case when a specimen is given a name denoting the locality in which it was originally found, and subsequently appears in other parts of the world. A further consideration of the structure and systematic position of this coral will be found in the systematic part of this paper.

Family GUYNIIDÆ.

PYROPHYLLIA INFLATA Hickson [25]. (Pl. LVII. figs. 8–11; Pl. LVIII. figs. 18, 19.)

About sixty specimens of this species were obtained on a gravelly bottom at a depth of 156 fathoms in the Gulf of Oman. Professor Hickson has added some further notes to his original description of this species at the end of this memoir (p. 1039).

FLABELLUM MAGNIFICUM v. Marenzeller [28.] (Pl. LVII. figs. 1–3.)

Corallum fan-shaped, wall and septa very thin and delicate. Numerous rootlets descend vertically downwards, each such rootlet communicating with two interseptal chambers on opposite sides of a septum, and firmly fixed on a mass of mud and serpulid tubes. Calice oval in outline, but constricted in the middle of the short diameter; practically semi-circular at the ends of the long axis. Two specimens, measuring as follows:—

	I.	II.
Height	30 mm.	15 mm.
Calice { Long diameter	60 „	40 „
Calice { Short diameters		
{ Greatest width	40 „	26 „
{ Least width	30 „	25 „
Number of septa	175	96
„ „ primary septa	24	24

Costæ faintly indicated throughout entire height of the corallum which is also marked with fine wavy transverse accretion lines. Septa in six systems of six cycles of which the sixth cycle is incomplete, while there are present a few rudimentary septa of a seventh cycle. Those of the first three cycles equal and reaching the columella, edges vertical, entire until within about 4 mm. of the columella where a few coarse denticulations may be present; beset with minute blunt spines arranged in transverse and radial rows. Septa of lower cycles become successively smaller. Columella parietal, only slightly developed.

Locality. Telegraph Cable, Persian Gulf. Depth not recorded.

In the larger specimen there are 175 septa arranged as follows *:—

	Number of septa.	Number of septa of 6th cycle wanting.	Number of super-numerary septa of 7th cycle.
Chamber 1	31	3	2
„ 2	25	7	none
„ 3	30	2	none
„ 4	26	6	none
„ 5	30	2	none
„ 6	33	5	6
Total	175	25	8

This coral differs from v. Marenzeller's species in its smaller size and the presence of numerous rootlets. Gardiner [19] has shown that the presence or absence of such rootlets is a variable character, and he has described rootlets in *Flabellum rubrum*, a species in which they had not previously been recognized.

v. Marenzeller's species was made for a single specimen, and as the agreement between the calicular and septal characters of the specimens under consideration and those of the type are so similar, it has been considered advisable not to separate them.

Family TURBINOLIIDÆ.

Genus HETEROCYATHUS.

The genus *Heterocyathus* has been critically examined by Gardiner [20], who had at his disposal a very large number of specimens. He absorbed the species of Semper and Rehberg in a single variable species originally described by Milne-

* The septa are considered as being divided into six chambers, bounded by primary septa; the chambers are considered in rotation beginning with one to the right-hand side of a directive septum.

Edwards & Haime [29] as *Heterocyathus æquicostatus*; to this Bourne [6] has since added *Stephanoseris rousseaui.*

In the large collection of corals from S. Africa, Gardiner recognized two types with the following diagnostic characters :—

Type I. Costæ equal in size, rounded and covered with low granules (Pl. LVIII. fig. 12), small intercostal spaces; base smooth, low granules, only traces of costæ; theca with thin upper edge, never more than 1 mm. above columella; septa in four cycles, thick with narrow interseptal spaces, average exsertness 1·5 mm.; cycle i. broader and more exsert than cycle ii., ii. than iii., iv. more exsert than iii., higher on either side of i. than of ii. Sides set with low ridges, edges not toothed; commonly certain ones, or all, coloured black; pali before all cycles, large and conspicuous; columella a mass of rods decreasing in size and height from the pali towards the centre of the axial fossa, densely packed together.

Type II. Costæ of cycles i., ii., and iii. larger than iv., which consists of a row of separate granules rougher and higher than in Type I, with broader intercostal spaces (Pl. LVIII. fig. 13); base roughly granular, costæ sometimes extending on to it; theca with thin upper edge, generally 2 to 3 mm. above the top of the columella; septa in four cycles with a tendency to have some of a fifth cycle represented, thin with broad interseptal spaces, average exsertness 3 mm.; ridges on sides conspicuous, edges toothed towards centre of calice; all the same colour, white or some shade of grey; no proper pali or columella; septa iv. fuse with septa iii., and these again with ii.; septa i. generally separate, but in the centre fuse with the rest forming a mass of trabeculæ covered by fine points which run up along the septa of cycles i. to iii. for some distance, almost like fine teeth.

In describing the collection of Mr. J. J. Simpson and Dr. Rudmose-Brown from Burma, Miss Poole [24] recognized the Gardiner's two types, and added a third type with a fifth cycle of septa, four crowns of nodular pali, and a deeper fossa.

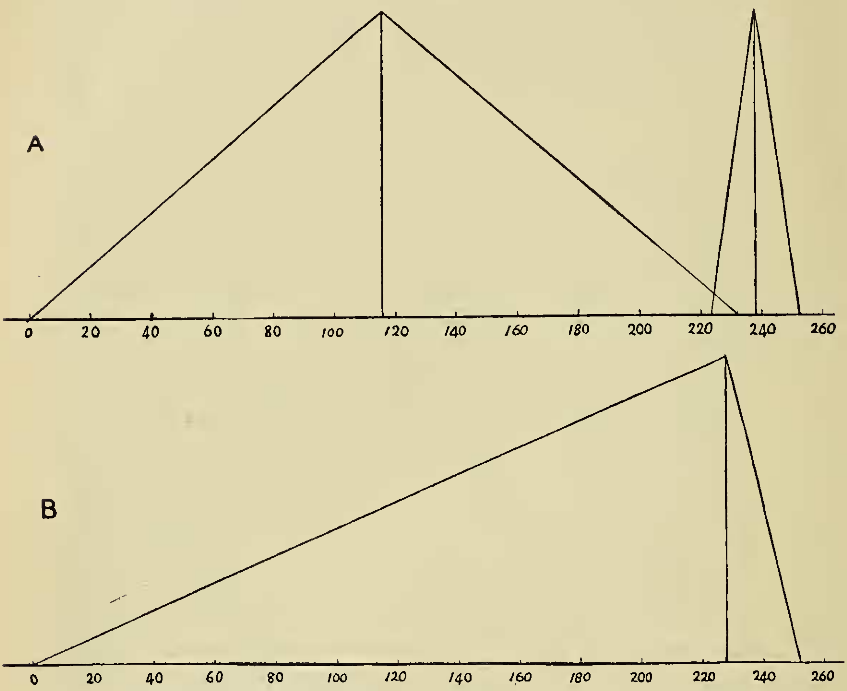
I have been able to re-examine the collections described by Professor Gardiner and Miss Poole, and, so far as the former collection is concerned, the two types are sufficiently different, in my opinion, to be regarded as two species. Gardiner himself has described them as "two perfectly distinct modes of growth, almost two varieties." I have searched in vain for intermediates, and although I had no difficulty in picking out the two specimens which the author describes as doubtful, they are both too much broken and corroded to afford any clear evidence that they represent a form intermediate between the two types. The general facies are entirely different. In Type I, the tendency is for the base to be broader than the calice in correlation with rounded granular costæ, thick septa, practically no fossa, and a papilliform well-developed columella. In Type II, the tendency is for the coral to taper away to a point from a circular calice; such is the form of the only known example without a commensal

Aspidosiphon; the flat base of the normal specimen is never so large as the calice, and this shape is invariably in correlation with alternating costæ, thin septa, a deep fossa, and an ill-defined columella.

The characters of the costæ of the two types are very definite. Fig. 12 on Plate LVIII. represents two adjacent costæ of Type I, low broad ridges, covered all over with fine uniform granules; the intercostal furrows are small and shallow. Fig. 13 on Plate LVIII. represents two adjacent costæ of Type II: on the right is the type of costa which corresponds to septal cycles i., ii., and iii., a prominent exsert ridge, on which the granulations tend to become regular transverse bars; on the left is a costa corresponding to septal cycle iv., slightly less exsert, and beset with very irregular coarse granulations; the intercostal furrows are deep. These marked differences, always in correlation with the differences of the calicular characters to which reference has already been made, are too consistent to retain both forms in the same species. True, there are many examples of Type I which have an alternation of broad and narrow costæ, but such costæ are always alike in being low and uniformly granular; the alternation of coarsely granular costæ and much exsert narrow costæ is never discernible. In some, however, there is a tendency for the costæ of Type I to become more exsert and more coarsely granular at the calicular margin, but this generally occurs where the whole growth of the coral has been distorted by being fixed to an abnormally large shell, and it might be thought that this distortion had influenced the form of growth. Indeed, it suggested the possibility that the shell on which the coral fixes itself, and the position which that shell assumes within the actual body of the coral, might influence the mode of growth to such an extent that not only the general shape but the character of the septa and costæ might be controlled. This, however, is not the case. There are well-defined examples of Types I and II both fixed on exactly similar shells: in some the *Aspidosiphon* in corals of both types is coiled horizontally forming a flat base, in others the corals are fixed to shells which lie sometimes horizontally, sometimes vertically within the coral zoophyte, and there are always examples of both types harbouring Aspidosiphons in shells which assume either position; so that the species of shell or the position it assumes exercises no influence on the manner of growth of these two well-defined types. Such types vary about two distinct modes, with a slight overlapping of the extremes of variation; and are not themselves the extremes of a single growth mode. The relation of the species to each other is represented in text-fig. 216.

Of some 252 individuals in the South African collection, there are 225 of Type I and 19 of Type II, and 8 which have characters common to both types. The characters which separate the two types cannot be measured and given numerical values; consequently in text-fig. 216 A the point about which the two growth-modes vary is purely arbitrary, but the number of individuals which vary about these points is a real number, and represents the two distinct growth-modes of two different species. If the two types were varieties of a single growth-mode, the variation might be expressed by such a diagram as text-fig. 216 B, but that would represent a condition of affairs wholly contrary to the numerical facts; for the intermediates, which in reality are less than a thirtieth of the whole number, here represent the greater number of forms.

Text-fig. 216.



A.—A diagrammatic representation of two species which vary about two distinct modes, the extremes of which converge towards one another. The abscissæ give numbers which vary about each mode respectively.

B.—A diagrammatic representation of a single species varying about an imaginary mode.

Type I is undoubtedly the *H. æquicostatus* of Milne-Edwards & Haime, although, as I shall show, there are considerable variations within the type. Type II is probably identical with Verrill's [42] *H. alternatus*, a species which has escaped the notice of several authors. This species possesses all the characters which separate Gardiner's Type II from Type I,—the base smaller than the disk, with a slight constriction above it, and then walls spreading obliquely outwards to the edge of the disk, alternating costæ, paliform teeth exsert before all septal cycles except the last, and an ill-developed papillose columella which scarcely rises above the surface of the broad shallow central fossa.

When Miss Poole stated that the forms in the Burmese collection belonged to three different Types, two of which were identical with Gardiner's Types I and II, she had not the advantage of seeing the actual specimens, and was in error. All the Burmese forms belong to Gardiner's type I, but they show great variation, and in order to justify their inclusion with *H. æquicostatus* three types must be recognized. These types may be called A, B and C to avoid confusion, but it must be understood that they correspond with Miss Poole's Types I, II & III.

Type A = Type I as defined by Gardiner. There is normally a single small aperture on the basal surface in addition to the opening of the *Aspidosiphon* chamber. In a few, this additional aperture is absent, whilst in others, two or at most three such apertures occur.

Type B is a much lower flattened form without a fossa; a tendency for the costæ to alternate; four septal cycles, the exsertness of the septa of the fourth cycle on either side of the primaries is very marked, and the joining over the tertiaries and secondaries gives a characteristic star-like appearance; the columella is less well-developed, it is a compact trabecular mass, and not distinctly papilliform as in Type A; the pores of the endodermal canals are more numerous, and are not restricted to the base, but are distributed irregularly round the lower part of the corallum.

Type C is a taller form, the base tends to equal the disk in diameter, and the walls are nearly perpendicular; a fifth cycle of the septa is present; there is a distinct fossa, and the centrally depressed columella is a trabeculate mass as in the previous type; the pores of the endodermal canals are disposed in a ring a little below the calicular margin.

In defining these three types, I have retained Gardiner's Type I and Miss Poole's Type C in order to avoid confusion as far as possible; but it must be borne in mind that Type B as here defined is very different from Gardiner's Type II.

Practically the whole of the South African collection belongs to Type A, the Burmese collection belongs to Types B and C; the specimens Miss Poole described as belonging to Type I should be included in Type B. The Ceylon collection described by Professor Bourne is somewhat intermediate between Types A and B. These three types will embrace the species of Semper, Rehberg, and Alcock*.

H. parasiticus Semper [**38**]. Intermediate between Types A and B.

H. philippinensis Semper [**38**]. Two types. Pl. xx. fig. 12 is Type B. Pl. xx. figs. 13 & 14, Type C.

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* I have not considered *H. sulcatus* and *H. lamellosus* Verrill, and *H. cochlea* Gmelin, as I have not been able to obtain first-hand reference to these species.

H. pulchellus Rehberg [**37**]. Intermediate between Types B and C. General facies, fifth septal cycle and depressed columella, Type C. Alternating costæ and distribution of lateral pores, Type B.
H. oblongatus Rehberg [**37**]. Type C.
H. wood-masoni Alcock [**1**]. Type B.

The specimen from the Persian Gulf also belongs to Type B.

The other specimens of *Heterocyathus* in the Persian Gulf collection constitute a new species. The tendency to remain conical is very marked; the costæ are distinct from those of other species; and the uniformity in size separate it sufficiently until a good series of intermediates are found which will link it up with *H. alternatus*.

I therefore recognize in the genus the following species:—

1. *H. æquicostatus* Milne-Edwards & Haime.
   Stephanoseris rousseaui Milne-Edwards & Haime.
   H. parasiticus Semper.
   H. philippinensis Semper.
   H. oblongatus Rehberg.
   H. pulchellus Rehberg.
   H. wood-masoni Alcock.
2. *H. alternatus* Verrill.
   H. æquicostatus (Gardiner's Type II).
3. *H. heterocostatus*, sp. n.

Heterocyathus æquicostatus Milne-Edwards & Haime [**29**].

A single specimen belonging to Type B. Costæ, equal in number to septa, extend to base, beset with irregular spines. Base roughly granular. Slight calicular fossa. Septa in six systems of four complete cycles, very spiny; those of the fourth cycle fuse with those of the third, and these in turn fuse with those of the second. Inner margins of septa pass imperceptibly into the trabecular columella.

Locality. Telegraph Cable, Persian Gulf. Depth 40 fathoms

Heterocyathus heterocostatus, sp. n. (Pl. LVII. fig. 6; Pl. LVIII. fig. 14.)

Corallum simple, free, variable in shape from a low discoid form to a conical cornuate form. Upper part of corallum deeper in colour than base. Height varies between 3 mm. and 7 mm., and calice between 3·5 × 3 mm. and 6 × 5 mm. Costæ of two distinct types. Those corresponding to the septa of the first, second and third cycles are visible from the base to the tip of the calice, prominent sharp ridges with a single series of coarse granulations; the alternate costæ, corresponding to the septa of the fourth cycle, extend only about half-way down the corallite from the lip of the calice; they are less prominent, and beset with numerous irregular granulations. Calice slightly elliptical, open, deep. Septa in four complete cycles. Primaries large, very prominently exsert; quaternaries join over the tertiaries, and again deep down in the calice over the secondaries; quaternaries on either side of the primaries much developed, and prominently exsert in the manner typical of the genus *Heterocyathus*; all septa beset with numerous fine granulations arranged in radial ridges. Pali in the form of small denticulations, which pass imperceptibly into a parietal, fasciculate, centrally depressed columella. At the base, a circular aperture leads to an *Aspidosiphon* chamber containing a small Gastropod shell, in which a Sipunculid lives commensally with the coral zoophyte.

Nine specimens.

Locality. Karachi. Depth 15–40 fms.; bottom, shell-sand.

PARACYATHUS CAVATUS Alcock [1]. (Pl. LVII. fig. 5.)

Corallum simple, fixed by spreading base and expanding slightly to lip of calice. Height varies between 15 mm. and 20 mm., but the shortest has the largest calice. Calice variable in shape, probably owing to local surroundings; in some specimens calice is circular, in others oval, while others have various indentations and excrescences. Diameters of calices 15 × 15 mm., 16 × 12 mm., 17 × 10 mm., 18 × 15 mm., 20 × 13 mm., 20 × 18 mm. Costæ visible from base upwards, low broad ridges covered with minute granulations, corresponding to each septum; towards the lip of the calice these costal ridges become more marked, and somewhat stouter and more exsert costæ alternate with slightly smaller costæ. This alternation of larger and smaller costæ is apparent in some specimens at the extreme base of the corallum as well as at the calicular margin. Septa close, not markedly exsert; the size of the septa and the extent to which they are exsert diminish in a descending order of magnitude according to the cycle to which they belong: those of the first cycle are larger than those of the second, the second than the third, and so on. They are uniformly covered with minute granulations, which are arranged in a series of longitudinal and radial rows. The calice is widely open, and the inner margins of the septa are cut up into large irregular nodules representing small pali, which pass imperceptibly into a fasciculate parietal, centrally depressed columella. There appear to be typically five orders of septa, but those of the lower orders are not always easy to interpret. The primaries are always large and extend to the columella; their paliform nodules are slightly larger and more projecting than those of the septa of lower orders; the septa of lower orders tend to fuse together near the columella, and pass into it as an ill-defined mass of minute pali. The larger size of the primary septa and the grouping together of those of other orders give a hexagonal starlike effect to the calice. In none of the seven specimens from the Persian Gulf are the five cycles complete, although in one there are 94 septa, only two septa of the fifth cycle being missing.

In the specimen figured (text-fig. 217), however, there are also

94 septa, but here the arrangement is not so simple: in one lateral chamber on each side between the primary and secondary septa the fifth cycle is unrepresented, there being only three instead of the normal seven septa. On the other hand, in both the apical

Text-fig. 217.

Diagrammatic plan of the septa of *Paracyathus cavatus*. The primary and secondary septa are black, the tertiaries are cross-hatched, the quaternaries are crossed with diagonal lines, the quinaries are left blank; i, ii, iii, iv, v, septa of the first, second, third, fourth, and fifth cycles.

chambers at one end of the long axis there is an excess of septa. In both chambers, between the primary and secondary septa on the one side, and the primary and secondary septa on the other side, there are more than the normal number of septa. It appears as if the tertiary septa of both these chambers had been split by a wholly superfluous quaternary septum, while in one case a quaternary septum has been further split by a supernumerary quinary. The same phenomenon is apparent to a greater or lesser degree in all the remaining five specimens. In one specimen there is a sudden outpushing of the wall of the calice between a primary and a tertiary septum, in which there are no fewer than nine instead of the normal three septa; in every case there is a costa to correspond with each septum, and the alternation of large and small septa and costæ is maintained.

Seven specimens fixed on to a mass of mud, shell and serpulid tubes.

Locality. From Cable 60 miles S.W. of Bushire, Persian Gulf. Depth 30 fms.

Two specimens are infested by the Cirriped *Pyrgoma stokesii*, which forms a bulbous gall within the wall of the coral (Pl. LVII. fig. 5 *c*). This distortion does not, however, interrupt the regularity of the costæ, which are distinctly visible on the outside of the parasitic chamber; nor does the presence of this parasite appear to affect the number of septa; there is no excess or shortage of septa in the attacked specimens beyond that which is normally observed in the unattacked individuals.

Genus Trematotrochus T. Woods [**39**].

Trematotrochus zelandiæ. (Pl. LVII. fig. 4; Pl. LVIII. figs. 15–17).

Conocyathus zelandiæ Duncan [**14**].

Corallum regularly conico-cylindrical, free, without trace of attachment. No epitheca. Height of largest specimen 7 mm., diameter of calice 3·4 mm. Costæ in four complete cycles, prominent, smooth, and equal in the upper part of the corallum. Only those of the first two cycles extend to the base; those of the third cycle extend downwards for about three-quarters, and those of the fourth cycle for a distance varying between a third and three-fifths of the height of the whole corallum. The costæ between those of the second and third cycles are longer than the costæ between those of the first and third cycles; they do not join those of the preceding cycle, but there is a thickening of the costæ of the first three cycles below the point at which that of the succeeding cycle ends. Intercostal furrows penetrated by minute, regularly disposed perforations (Pl. LVII. fig. 4). Calice circular, no fossa. Septa in six systems of three complete cycles, all exsert, those of the first cycle more prominently so than those of the succeeding cycles; very thin and beset with small spinous granulations. Septa of the third cycle join those of the second a short distance below the lip of the calice; they are incomplete at their inner margins, large fenestrations occurring at the point where the septa of the third cycle join those of the second, and those of the first and second join the columella. The lower fifth of the corallum has been filled up internally by a secondary deposit of calcareous matter, but the outline of the original structure is faintly discernible in photographs of sections at this level, and reveals that the columella is parietal, formed by the union of the inner ends of the septa.

Three specimens.

Locality. Persian Gulf. Depth not recorded.

The genus *Trematotrochus* was proposed by Tenison Woods [**39**] for a fossil from the Miocene of Australia. The coral had all the characters and appearance of a Turbinoliid, but with the important difference that the wall was penetrated by large perforations between the costæ, giving free communication between the interseptal chambers and the exterior.

This remarkable coral did not receive the attention it deserved, and subsequent authors received sceptically the statement that these perforations were really present; for the point called in question the validity of the division of the Madreporaria into Perforata and Imperforata. Duncan [**15**] pointed out the difficulty of placing this genus, but referred it to the Turbinoliidæ in close relation with *Turbinolia*, *Stylocyathus*, *Conocyathus*, and *Bistylia* *.

In a series of papers published in the Transactions of the Royal Society of South Australia, Dennant [**7** & **8**] has since described six more fossil forms and one recent form (*T. verconis*) from Australia and Australian Seas. In the first of these papers he describes two species from Eocene and one species from Miocene deposits. The recent species was found in St. Vincent's Gulf and Backstairs Passage at depths of from 15 to 22 fathoms. All have the characteristic perforations, which fact caused him to remove the genus altogether from the Turbinoliidæ and place it among the Eupsammiidæ. Later he described three different species from older Eocene beds than those in which his previous species were found, and in two of these the perforations do not pierce the wall, but are merely pore-like cavities extending half-way through the thickness of the wall like the intercostal dimples of some Turbinoliidæ. This made him put the genus back among the Turbinoliidæ, and he referred to Gregory's [**23**] suggestion that the Perforate type of coral has been derived from the Imperforate. He further remarked on the wide distribution through time of the original species *T. fenestratus*, and appended a drawing of a portion of the wall of one of them, placing the existence of the pores beyond all suspicion of doubt. All the previously described species come from Australia, and Dennant pointed out the

* Duncan uses the phrase "one of the species" as if more than one species were known. At the time of the publication of his paper (1885) I am not aware that any other species had been described.

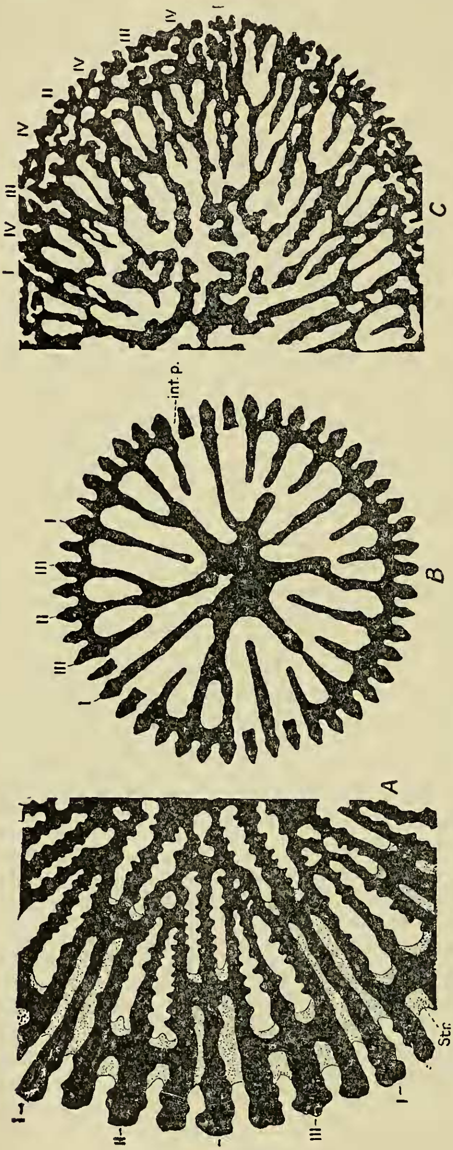
occurrence of a recent form as evidence of the close relationship between the living and fossil fauna of that country. He made no attempt to discuss the significance of these forms in connection with the existing classification of the Madreporaria, but dismissed the subject with the single statement—"the broad distinction usually made between perforate and non-perforate corals breaks down."

The occurrence of another recent species of this problematical genus again forces the subject on the attention of the systematist. That it is a *Trematotrochus* is, I think, unquestionable. It agrees with Dennant's latest definition in all points but one:—He has described the septa as being solid; but in *T. zelandiæ* the septa are incomplete, large fenestrations occurring at the point at which the tertiaries join the secondaries, and the primaries and secondaries join the false columella. Realizing that the existence of these fenestrations and of the pores in the outer wall might again be doubted (having already admitted that these latter are minute and difficult to see), I have ground sections of one specimen, thinking that actual photographs would be more convincing than external observations. These sections have been made at intervals of $\frac{1}{20}$ mm. and the entire coral has been ground away; every section was photographed at a magnification of 20, and from these photographs a wax model has been constructed. There is, therefore, a permanent record of the structure of this most interesting coral, and it would be idle to deny the existence of either thecal pores or septal fenestrations. But in spite of this, I think that it is rightly placed among the Imperforate corals.

In text-fig. 218, A and C are diagrammatic representations of transverse sections of portions of the wall of a *Heterocyathus* and a *Heteropsammia* (after Bourne [6]), for comparison with B, a transverse section of *T. zelandiæ*. The *Heterocyathus* has a solid theca embedded in stereoplasm. The *Heteropsammia* has a porous spongy wall. A glance at the *Trematotrochus* will show that the extremely thin wall is incomplete, and that here and there are small communications between the interseptal chambers and the exterior; but it could not be regarded as a "porous cœnenchyme" such as is diagnostic of the division Perforata. The condition is much more that of a Fungiid which has grown conically instead of spreading out with a widely open oral surface, with that part of the wall between the perforations representing synapticula. In some of the fossil forms the perforations are so large and the intervening solid structure little more than a narrow bar, that the comparison with synapticula is more striking than in the present instance. The analogy, however, must not be pressed too far, but it widens the gulf between *Trematotrochus* and the Perforata, and tends to justify its inclusion among the Imperforata.

Another point to be emphasized is the localities in which the species are found. Hitherto the eight species of the genus were all found in the limited area of Australia and the seas round that continent and New Zealand; but now we find it in the

Text-fig. 218.



A. Portion of a diagrammatic section through the corallum of *Heterocyathus æquicostatus* (after Bourne).

B. Diagrammatic section through the corallum of *Trematotrochus zelandiæ*.

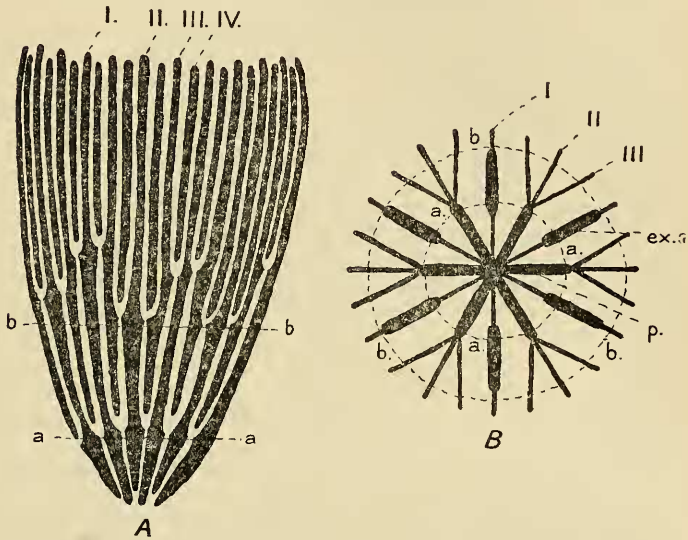
C. Portion of a diagrammatic section through the corallum of *Heteropsammia michelini* (after Bourne).

i, ii, iii, iv, septa of the first, second, third, and fourth cycles; *Str.*, stereoplasm; *int. p.*, intercostal pores.

Persian Gulf. The identity of the last with *Conocyathus zelandiæ* has already been pointed out in the introductory remarks of this paper, and the occurrence of the same species in localities so far apart is remarkable.

I had hoped that the sections might throw some further light on the question of septal sequence, but unfortunately the lower fifth of the coral has been filled up solidly by a secondary deposit of calcareous matter, and the interseptal chambers do not begin to appear distinctly until a level is reached where twelve septa and twenty-four costæ are already present. If it

Text-fig. 219.



A. Diagrammatic plan of the costæ of *Trematotrochus zelandiæ*, showing the difference in length of the costæ of the fourth cycle. i, ii, iii, iv, costæ of the first, second, third, and fourth cycles.

B. Diagrammatic plan of the septa of *Trematotrochus zelandiæ*, representing the exsert peripheral portion of the primary septa, and the exsert pali of the secondary septa. i, ii, iii, septa of the first, second, and third cycles; *ex.s.*, exsert portion of the septa of the first cycle; *p.*, pali.

may be taken that the costæ correspond to the septa and that the base of a coral represents the earliest formation, it might be objected that Pourtalès' law for septal sequence has not been followed in this case; for the costæ which extend to the base, twelve in number, are those corresponding to the first and third (according to Pourtalès [35]) cycles of septa. That is to say, if the secondary septa split peripherally in a Y-shape, and a tertiary septum grew up between the arms of the Y, the septa generally spoken of as secondary and tertiary are named conversely to the order in which they appear in ontogeny. But it must be remembered that the stem of the Y is also the representative of the secondary septum according to either the popular or Pourtalès' nomenclature; and these septa still exist in their normal position midway between the primary septa, and project upwards as pali, or paliform lobes: in the lower portion of the colony, before the secondary septa have begun to branch, the costæ corresponding to them are also unbranched, and extend to the base. A comparison of the diagrams A, B, in text-fig. 219, illustrates this point.

Diagram A represents a plan of the costæ and B a plan of the septa; in A a line "*a a*" has been drawn across the lowest part of the corallum, and in B a corresponding circle "*a a*" has been drawn round the inner part of the septal plan; in both, the costæ and septa respectively of the first and second cycles are present; presumably the coral must at one time have passed through a stage when these cycles only were present. In *T. fenestratus* this is the arrangement in the adult. Again, another line "*b b*" is drawn across A at a higher level and a corresponding circle "*b b*" on B; in both, the costæ and septa of three cycles are present. When the secondary septa branched peripherally, new costæ arose in connexion with these branches, and the original secondary costæ remained in connexion with the inner unbranched part of the secondary septa which persist as pali or paliform lobes. Bourne [6, text-fig. I. 2] has given a comprehensive diagram illustrating the relation of septa and pali according to Pourtalès' principle: diagram B illustrates the arrangement in *T. zelandiæ*, which is entirely in agreement with it.

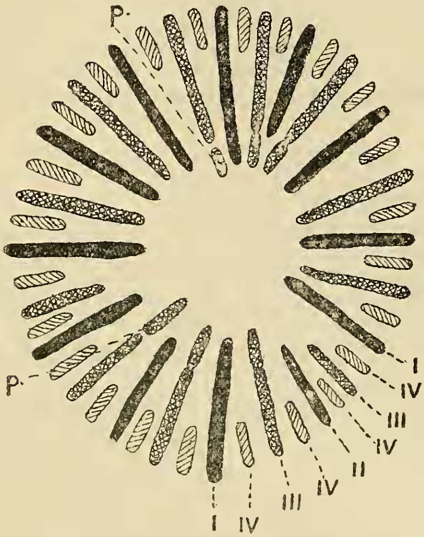
The fact that the costæ of the fourth cycle are of different lengths (see text-fig. 219 A, iv) is in accordance with Duerden's [11] account of the septal sequence of *Siderastræa radians*, in which he states that new mesenterial pairs appear in some interseptal chambers, before those in others of the same cycle.

Agelecyathus persicus Duncan [14].

Corallites rising from an encrusting base, expanding slightly from base to calice. Calice elliptical, depressed at one end of the long axis. Height of corallum from 5–10 mm. at depressed end of the long axis, and from 15–20 mm. at the opposite end. Diameter of calice 9 × 7·5 mm. to 11 × 9 mm. The shape of the corallites suggests that the colony was fixed on a vertical surface, and the inequality of height in the two extremities of the long axis is a response to an effort on the part of the individual corallites to assume a vertical position. Costæ in four complete cycles, distinct from base upwards, slightly exsert and finely granular. Septa in six systems of four cycles of which the last is incomplete, although all the costæ of the fourth cycle are present; septa of the first two cycles more exsert than those of the third cycle; all three cycles reach the columella;

septa beset with minute granulations arranged in radial ridges. An incomplete single crown of pali before the septa of the third cycle. Columella fascicular.

Text-fig. 220.



Diagrammatic plan of the septa of *Agelecyathus persicus*. Septal orders represented as in text-fig. 217. Six detached pali are represented. i. ii, iii, iv, septa of the first, second, third and fourth cycles; *p.*, pali.

A single specimen consisting of five individual corallites arising from a common encrusting base.

Locality. From Cable 60 miles S.W. of Bushire, Persian Gulf. Depth 30 fms.

Before some of the septa of the third cycle there are distinct upwardly projecting lobes corresponding to pali. Thus in the calice figured (text-fig. 220) there are six such pali opposite six septa of the third cycle, three at each end of the long axis; there are two less conspicuous lobes before two septa of this cycle, while the remaining four septa of the third cycle have no trace of any such lobe. Milne-Edwards and Haime [**29**] divided the family Turbinoliidæ into two sub-families—the Turbinolinæ without pali, and the Caryophyllinæ with pali; and this classification has found more favour with subsequent authors than Duncan's [**15**] later classification, which divided the family into *Turbinolidæ simplices*, *Turbinolidæ gemmantes*, and *Turbinolidæ reptantes*, according to their habits of growth and reproduction. This coral affords evidence in favour of Duncan's classification; indeed it would be difficult to know in which of Milne-Edwards' and Haime's groups to place it, for here in a single calice is a combination of the diagnostic characters of the two sub-families: pali are present before some and not before other septa of the same cycle.

This specimen is considerably larger than Duncan's original example from the same locality, and differs from his figure of the type specimen in having the septa in the first two cycles much exsert; but he calls attention to the variability of the pali, the size and the number of the septa, as being features of the individual corallites. The similarity in other details is close.

Family Fungiidæ.

Fungia patella Ellis & Solander [**16**].

Three specimens from the Persian Gulf which are identical with Döderlein's figure [**10**, pl. i.] of the Cycloseris-form of *F. patella*, Wayland Vaughan's figure [**40**, pls. xxvii. & xxviii.] of *F. patella*, and Gardiner's figure [**18**, pl. xix.] of *Cycloseris hexagonalis*. They afford further evidence of the wide distribution of the species, and for the justification of absorbing the genus *Cycloseris* in the genus *Fungia*.

Locality. Two specimens from Shaikh Shuaib Island, Persian Gulf. Bottom, rock. Depth 10 fms. Exact locality of third specimen not recorded.

Family Eupsammiidæ.

Heteropsammia aphrodes Alcock [**1**].

Eight specimens each with a single calice. The inflated spongy exsert edges of the septa of the first two cycles are well developed.

Locality. Telegraph Cable, Persian Gulf. Depth 40 fms.

Dendrophyllia sp.? de Blainville [**5**]. (Pl. LVII. fig. 7.)

Colony bushy, springing from an encrusting base on which are numerous small individuals. Budding lateral or basal. Polyps occasionally joined by horizontal bars, but in every case such bars are inhabited by a small commensal worm, and have probably been formed in connexion with this parasite. Polyps tend to assume a vertical position, but one polyp which appears to arise from a horizontal bar is directed downwards. Size of the polyps very variable; some scarcely rising from the encrusting base; some attaining to a height of 25 mm. Calice varies between 2×2 mm. in the youngest to 7×6 mm. in the oldest individuals. Costæ distinct from base upwards, equal, granular, not exsert, correspond in number to the septa. Septa in six systems of four cycles with a few representatives of the fifth cycle, all irregular. Some septa of the lower cycles are grouped together round that of the preceding cycle in the typical dendrophylliid manner, while others extend to the columella, and are equal in size to those of preceding cycles. All septa are finely granular, the lower orders are perforate. Calicular fossa very deep. Columella fascicular, parietal; well developed in older individuals.

Locality. From Cable 60 miles S.W. of Bushire, Persian Gulf. Depth 30 fms.

With only a single specimen of a coral such as this, which exhibits such a wide range of variability, the creation of a new species has not seemed to me justifiable. I have, therefore, merely noted its characters and appended a photograph of the specimen, until such time as it may be found in greater numbers.

Note on Miss Harrison's memoir on some Madreporaria from the Persian Gulf, and some further notes on *Pyrophyllia inflata.* By Sydney J. Hickson, M.A., F.R.S., F.Z.S.

The manuscript of Miss Harrison's paper was sent to me shortly before she left this country for India, with a request that I would read it and revise it for publication. The number of species in the collection is small and there is only one that is new to science, but there are several points in the paper which it seemed to me required rather fuller consideration than she has given to them, and I have ventured therefore to write an addendum, leaving her original memoir intact. Had she remained in England I would have suggested the inclusion of these remarks in her paper, but under the circumstances, I think it is better to publish them under a separate title and thereby take the whole responsibility for them. I have rearranged the order of the species, furnished the list on p. 1019, and added the family names, but in other respects the paper is as it left her hands.

At the present time our knowledge of the fauna of the Persian Gulf is very limited. None of the great deep-sea exploring expeditions have visited it, and independent investigators with sufficient knowledge and energy in this region have been few and far between.

Mr. F. W. Townsend, of the telegraph staff of the Indian Government, has made a large and valuable collection of shells, and these have been described in a series of papers by Cosmo Melvill and Standen,* but so far as I can discover, very few genera and species belonging to other groups of marine animals have been recorded. The richness and interest of the Molluscan fauna suggests that many new forms have still to be discovered in the Gulf, but the subject of special importance that the study of this fauna would shed light upon, is the relation of the fauna of the Persian Gulf to that of the Mediterranean Sea. It has frequently been suggested that in the past there was a connexion between the Indian Ocean and Atlantic Ocean by way of the Mediterranean Sea; and, judging by the present day geographical features, it is probable that the last connexion between them

* For list of papers see Proc. Zool. Soc. 1906, p. 783.

was broken by the formation of the Isthmus of Suez. But the last connexion but one was that by way of a strait, of which the remaining part is now the Persian Gulf; and this gulf with its narrow outlet into the Indian Ocean, high temperature and great rivers, might be expected to retain some of the fauna which had been subject to very similar conditions in the South-east corner of the Mediterranean Sea. Melvill and Standen call attention to the considerable generic analogy between the Mollusca of the two regions, and point out that the species of the Persian Gulf show close affinities with South-European forms.

It would be quite premature to draw any far-reaching generalisations as to the distribution of Madreporaria from the few specimens that are here recorded, but attention may be called to one or two points of general interest.

The occurrence of *Pyrophyllia* in deep water in the Persian Gulf is interesting from the point of view of geographical distribution. Alcock [3] in his comments on the deep-sea Madreporaria of the Indian Ocean, calls attention to the "many intimate affinities of the fauna of moderate depths of the Indian seas with the North Atlantic fauna," and considers them "to be sufficient to suggest a direct sea-connexion, in the past, between the Atlantic and Indian Oceans, and the case of *Caryophyllia communis* and *Flabellum laciniatum* would indicate that the connexion was by way of the Mediterranean."

The case of *Pyrophyllia* and *Guynia* appears to me to give even stronger evidence of the truth of this hypothesis, than that of the two species quoted. The genera *Caryophyllia* and *Flabellum* are both very widely distributed recent corals, and it is possible that in comparatively recent times these two species may have had an almost cosmopolitan distribution. *Guynia* and *Pyrophyllia* are, so far as is known at present, very restricted in their distribution and are totally unlike any other recent coral—with the possible exception of the West Indian genus *Haplophyllia.*

Although so much alike in important characters, they are sufficiently distinct for us to believe that they were separated from one another at a very remote period. It is rather more difficult to believe that the Indian Ocean and Mediterranean specimens of *Caryophyllia communis* and *Flabellum laciniatum* can have undergone no differential change since the time when the Mediterranean Sea and the Indian Ocean were in communication. A second point of interest is, that the only other coral with which *Pyrophyllia* shows affinities, namely *Conosmilia*, should be found in the Tertiary deposits of Australia. Standing by itself, this is only one of those facts of geographical distribution which it is important to note but impossible to explain in a satisfactory way. But its importance as a fact is emphasized when it is placed side by side with the facts of the distribution of *Trematotrochus*.

As Miss Harrison points out, the specimens of *Trematotrochus* found in the Persian Gulf are closely related to species of corals from the Tertiary deposits of Australia, and to a recent coral found at depths of from 15 to 22 fathoms in St. Vincent Gulf,* and identical with a recent coral from "no very great depth" in Cook's Strait, New Zealand.

Of the geograpical distribution of the other species very little need be said. *Heterocyathus heterocostatus* is new, but a closely related species *H. æquicostatus*, of which one specimen was found, appears to be widely distributed in the Indian Ocean. *Paracyathus caratus* is found in the Indian Ocean and is said by Alcock to be closely related to the Eocene fossil *P. crassus* from the London Clay. *Agelecyathus persicus* was previously recorded by Duncan from the Persian Gulf, but was said to occur also off St. Helena. *Fungia patella* occurs in the Indian Ocean. The type specimen of *Flabellum magnificum* was found off Sumatra at a depth of 470 metres. The genera *Heteropsamnia* and *Dendrophyllia* appear to be widely distributed in the Indian Ocean. So far then as this small collection of corals is concerned, *Pyrophyllia inflata* is the only species that even suggests a former connexion of the Gulf with the Mediterranean Sea.

The genus *Pyrophyllia* was briefly described in the "Manchester Memoirs," 1910; but it may be convenient to take this opportunity of adding a few general remarks on the genus and of publishing some further illustrations (Pl. LVII. figs. 8–11; Pl. LVIII. figs. 18, 19).

Pyrophyllia inflata is a small unattached solitary coral, of about 4 to 5 mm. in length, and 1 mm. in diameter at the margin of the calyx.

The two most important characters are:—(1) Its very pronounced and invariable octoradiate symmetry, and (2) the presence on the external surface of well-marked accretion ridges with short but definite costal spines (text-fig. 221).

Pyrophyllia is related to the recent genus *Guynia*, and to the extinct Tertiary genus *Conosmilia*. The number of septa in *Pyrophyllia* and in *Guynia* is sixteen, and of these eight are larger and may be called the primary septa, and the remaining eight are smaller and may be called the secondary septa.

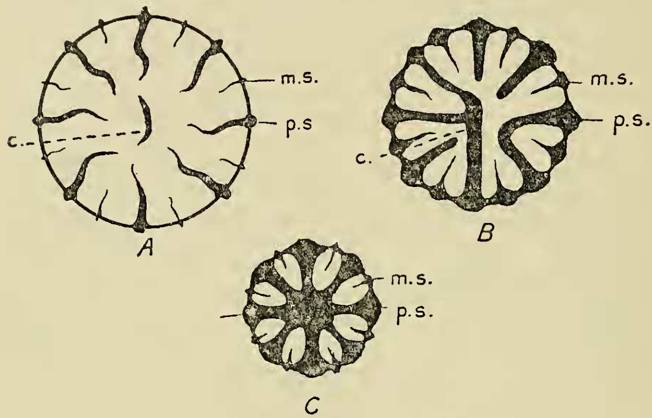
In *Guynia* one of the eight primary septa is larger than the others, this large septum being according to Duncan a "very marked rugose peculiarity." Moreover, in *Guynia* four of the primary septa are sometimes larger than the other four, so that according to Duncan the system of septa is four primary septa, four secondary septa, and eight tertiary septa.

In these respects and in others of less importance, *Guynia* seems to be distinct from *Pyrophyllia*. In the genus *Conosmilia* there is a more variable arrangement of the septa. In *C. elegans*, *C. lituolus*, and *C. anomala* there are eight primary septa, eight secondary septa, and thirty-two tertiary

* The specimens of this coral *T. verconis* were much worn and were no doubt dead corals when collected.

septa; but in *C. striata* there are only six primary septa, six secondary septa, and twelve tertiary septa. The more recently described species of this genus, *C. granulata* and *C. stylifera* (Dennant 7), agree with *C. striata* in the hexaradial arrangement of the septa. In *Conosmilia*, moreover, the accretion ridges do not appear to exist unless they are represented by the " beautiful herring-bone ornamentation of the surface."

Text-fig. 221.



Diagrammatic sketches of the septal arrangement of *Pyrophyllia inflata.*

c., columella; *m.s.*, secondary septa; *p.s.*, primary septa.

A. Arrangement of the septa just below the margin of the calyx. B. At the base of the calyx. C. In the lower parts of the coral. (From Mem. Manch. Lit. Phil. Soc. 1910.)

The columella of *Conosmilia* resembles *Pyrophyllia* in being laminate and in this respect differs from *Guynia*, in which the columella is cylindrical.

There has been a great deal of hesitation in giving the two genera *Guynia* and *Conosmilia* a definite resting-place in the system of corals.

Duncan * at first placed the genus *Guynia* in the Order Rugosa and in the family Cyathaxoniidæ, but subsequently removed it [15] to the family Turbinoliidæ. Miss Ogilvie placed it in her new family Amphiastræidæ †.

Duncan ‡ at first placed the genus *Conosmilia* in the Order Rugosa, family Stauridæ, but subsequently removed it to the family Astræidæ Simplices and placed it close to the genus *Trochosmilia.* Miss Ogilvie placed this genus in the family Turbinoliidæ.

In my preliminary account of the genus, I remarked that "it cannot be denied that *Pyrophyllia* has some characters reminiscent of the extinct Rugosa," but on reconsideration I do not feel

* Phil. Trans. R. S. 1872. † Phil. Trans. 1896. ‡ Phil. Trans. 1872.